Environmental performance of firms and waste generation in Tuscany

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ENVIRONMENTAL PERFORMANCE OF FIRMS AND WASTE GENERATION IN TUSCANY

di
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ABSTRACT

The problem of waste management has become a major issue in Europe, especially in countries with high population density, such as Italy. Although waste management was set as one of the four priorities of the European Commission for the years 2002 to 2012 (sixth Environmental Action Programme), total waste production in EU-27 is still increasing.

Under this perspective, the role of firms in source reduction (prevention, packaging reduction, recycling) has become crucial. An externality problem arises because the firm does not bear the full cost of waste production and management and there isn't a definite incentive to invest in a waste minimizing technology.

The aim of this paper is to shed some light on waste produced by firms in Italy, with a detailed analysis of firms located in Tuscany. As regards Tuscany, the analysis is be conducted at the micro level with a highly innovative panel dataset built by merging waste and balance sheet data. This dataset provides detailed information on firms sectoral and dimensional characteristics for a first assessment of the relationship between productivity, profitability and waste production at the firm level. Our estimation results show a waste saving behaviour for most profitable firms, with significant differences across firm dimension, sector of activity and localisation within the Region.

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1. Introduction

The goal of decoupling waste generation from economic activity is set as one of the most important of EU's Sixth Environment Action Programme. The three pillars of the strategy -- waste prevention, recycling and reuse and healthier final disposal – constitute the base of all actions directed to national governments, consumers and firms. Notwithstanding a vast set of economic instruments is used for this strategy, command and control measures appear as the most pervasive, while the Polluter Pays Principle (that implies that all waste costs should be covered by waste producer) is only loosely applied.

Determining the extent to which EU policies have effected changes in national waste management practices is a complex task. The waste management issue is particularly delicate and moreover, according to the subsidiarity principle, different levels of government are in charge of designing and implementing waste policy.

Data at EU level shows weak sign of decoupling between waste generation and economic activity (Table 1): total waste generation has decreased in 2008, but this seems to be linked more to the downturn of business cycle, than to an inversion of the previous trend. Moreover wastes generated by households, which are less than 10 % of the total waste generated in the EU, show an increasing trend almost everywhere in Europe[1].

Table 1 - Generation of waste by sectors (tonnes and kilos per capita)

	2004	2006	2008
Total (tonnes)	2.702.610.000	2.752.280.000	2.615.230.000
- All NACE activities (tonnes)	2.489.600.000	2.536.580.000	2.393.810.000
- Households (tonnes)	210.960.000	215.340.000	220.950.000
Total (kilo per capita)	5.516	5.569	5.244
- All NACE activities (kilos per capita)	5.081	5.132	4.800
- Households (kilos per capita)	431	436	443

Source: Eurostat (2011)

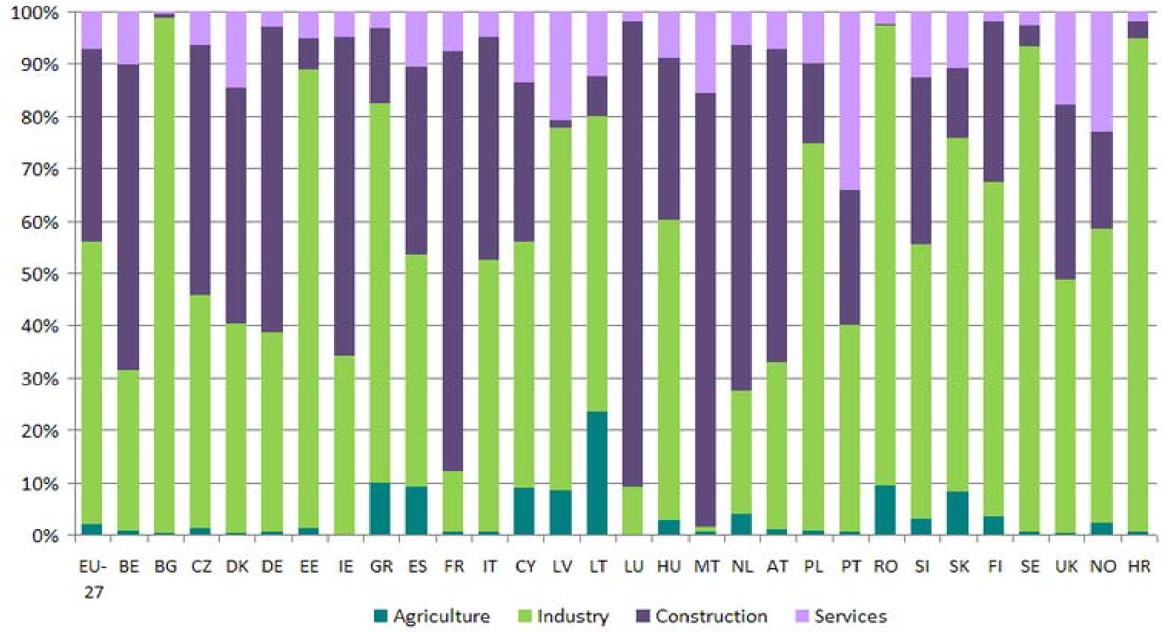
Even though the waste generated by economic activity is prevailing (90% of the total generated), most of analysis and quantitative information are focussed on municipal/household wastes. The European statistical regulation[2] has introduced the concept of "waste generated by household" that replaced the traditional municipal waste category, but this reformulation added complications to data comparability as some countries still fail to distinguish between the two.

Graph 1 shows the relative share of waste generation among economic activities in EU. Construction, mining and quarrying and manufacturing activities are the most important sources of waste in EU 27. This composition obviously reflects differences in the economic structure (specialization and firm dimension) and in waste policies implemented by member states. However, such a cross-country comparison should be regarded with caution since differences could also be due to non homogeneous data collection criteria.

[1] According to EEA, municipal solid waste levels have stabilized in EU 27 at 520 kg/capita. Municipal waste includes waste generated by households and other wastes (from small business activities, commerce and public institutions) collected by municipal authorities.

[2] Regulation (EC) No 2150/2002 of the European Parliament and of the Council on waste statistics. A new set of guidelines on waste statistics has been released by Eurostat in June 2010.

Graph 1 - Waste generated by economic activity, 2008 (in percent of non household waste)



Source: Eurostat, statistical database

Table 2 highlights the Italian waste generation trend, showing a very poor performance: waste generation increases for all sectors more than European average, with at a very high speed for Services (+44%).

Table 2 - Waste generated by economic activities and household in Eu and Italy (2004=1)

GEO/TIME	2004	2006	2008
Waste generation: Total			
European Union (27 countries)	1,00	0,98	0,90
European Union (15 countries)	1,00	1,04	0,99
Italy	1,00	1,12	1,13
Waste generation: Total Economic Activities			
European Union (27 countries)	1,00	0,98	0,89
European Union (15 countries)	1,00	1,04	0,99
Italy	1,00	1,13	1,35
Waste generation: Manufacturing			
European Union (27 countries)	1,00	0,95	0,90
European Union (15 countries)	1,00	0,95	0,91
Italy	1,00	1,01	1,09
Waste generation: Services			
European Union (27 countries)	1,00	1,06	0,94
European Union (15 countries)	1,00	1,08	0,97
Italy	1,00	1,43	1,44
Waste generation: Households			
European Union (27 countries)	1,00	1,02	1,05
European Union (15 countries)	1,00	1,00	1,02
Italy	1,00	1,04	1,04

Source: Eurostat, statistical database

It's clear that the Italian waste generation pattern is very far from European goals: notwithstanding a per capita value similar to the EU 15 average (but far higher than the new member states average) the Italian trend is far from stabilisation and there is no signal of decoupling[3]. Similarly, non-household production shows a much faster increasing trend in Italy. Even though municipal waste management has highlighted several problems and criticisms in the south of Italy, non municipal waste accounts for 90% of the total and appears as the main policy challenge to be explored.

2. Italian regulation: a brief overview on non-household waste definition

The national waste framework legislation[4] contains very general prescriptions for waste management and defines the responsibilities among levels of governments (Central Governments, Regions, Provinces, Municipalities). This general regulation classifies four groups of waste by means of two characteristics: hazardous/non hazardous and municipal (or urban) versus industrial (non household[5]) production. Classification of waste as municipal or as non-municipal involves important differences in terms of regulation and costs: municipalities are in charge of municipal waste, whereas non municipal waste should be disposed by producers.

Regions hold the responsibility for drawing up waste management plans to integrate waste collection, treatment and disposal within optimal management areas (ATO, Ambito Territoriale Ottimale). The regional authorities have also the responsibility to issue regional regulation on waste generated by economic activities (special waste), whose criteria are generally different from those for municipal waste. Finally, regional authorities set autonomously the landfill tax that can differ from region to region. The goal is preventing waste production and stimulating energy recovery from waste. The tax is calculated on the basis of the weight of waste disposal at landfills or in incineration plants without energy recovery. Tax rates range between 1 and 25 euro per tonne: € 1–10 for inert waste, € 5–10 for other non municipal waste and € 10–25 for municipal waste, on regional basis[6].

Local Authorities have the responsibility to organise municipal waste collection and management. However, the non-hazardous industrial waste can be "assimilated" to ordinary municipal waste by Local authorities' regulation and it becomes equivalent to the municipal waste in every aspect, either for collection, transport and disposal, or for the basis of the fee payment. Non-household waste can be assimilated also by special agreement between producers and public service waste collector.

[3] Moreover the European Court of Justice has sentenced Italy for infringements of several directives, such as the Hazardous Waste and Landfills Directive, since 2007 and the region Campania waste crisis is still far from being solved. An analysis of Environmental Kuznetz Curve for municipal waste in Italy can be found in Mazzanti, Montini, and Zoboli (2006).

[4] Decree 152/06.

[5] Non household waste productions, i.e. waste generated from economic activity, are named as "special waste" in the Italian law.

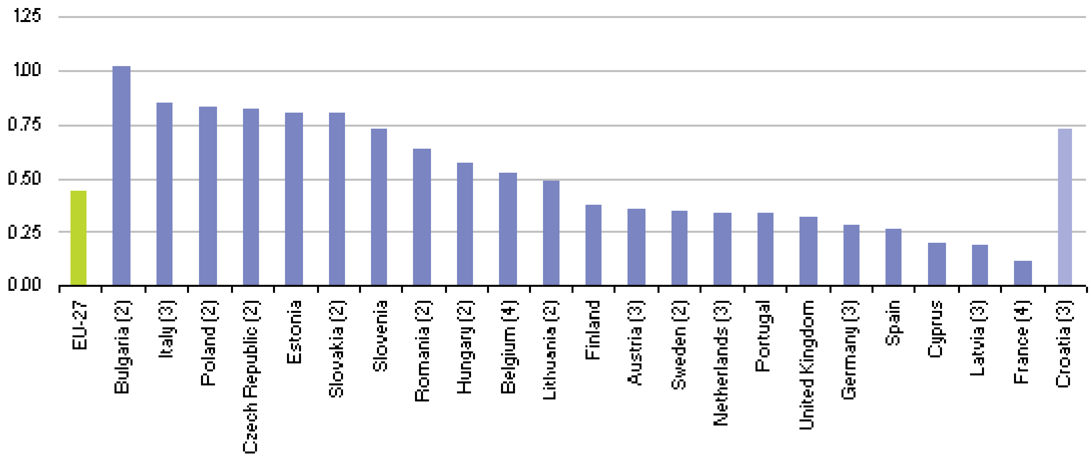
[6] These tax rates appear much lower than European average rates: landfill tax is on average 60€ in Austria and Denmark and can reach 107€ in the Netherlands. See Cewep (2010).

3. Environmental efficiency and firm profitability: a causality dispute

The result of this highly fragmented legislation is a picture of extremely diversified waste management performance among areas. Efficiency is usually much higher in the northern areas, but several examples of excellence can be found in every region of the country.

Inefficiency leads to higher cost for Italian households and firms: CEWEP estimates a net average cost of landfilling of 80 euros, much higher than the EU average . Moreover, data on environmental protection expenditure in Europe shows that Italian industrial firms spend more than 0,8% of GDP, whereas the EU average is around 0,4% of GDP (graph 2). In Italy this kind of cost mainly finances waste management and it's concentrated on current expenditure[7]. According to this data, the burden of environmental regulation on waste cannot be considered as a negligible cost for Italian firms.

Graph 2 - Industrial environmental protection expenditure (% of GDP)



(1) Denmark, Greece, Ireland, Luxembourg and Malta, not available.
(2) 2007.
(3) 2005.
(4) 2004.
Source: Eurostat (env_ac_exp1 and tec00001)

However, there is a growing strand of literature about the link between environmental regulation/environmental performance and firm financial outcomes. This literature suggests that any environmental effort improving environmental performance can be profitable in the medium run: the rationale behind this view – known as the win-win hypothesis – is that firms that adopt "green" technology and apply good environmental practices can obtain a competitive advantage, thus increasing their profits and improving their market shares (Porter and Van der Linde, 1995; Hart, 1997). According to this view, a better environmental performance can lead to an increase in profits through the possibility to innovate, differentiate products, advertise better, and reduce energy services and regulatory costs, among which taxes and pollution quotas. This view is challenged by the more traditional approach claiming

[7] The most recent Italian data (Istat, 2011) shows that firm expenditure for waste management increased by 111% between 1997 and 2009.

that additional costs to improve environmental performance are non negligible and they end up reducing profits[8]. Complying to environmental regulation or improving environmental performance imply new activities and several types of cost like changing production process, adding an end of pipe phase of the production process, innovating. In all these cases an investment effort seems unavoidable.

The empirical literature initially has tried to confirm the idea that "it pays to be green" by estimating a relation between some profitability index - based on market value or balance sheet data[9] - and the environmental effort of the firms (mainly based on publicly index, or rewards or fees linked to environmental regulation, or to gas emissions)[10]. The problem is that the significant correlation found by many studies does not demonstrate the causality direction or can be the result of spurious correlation, as in the case of firms operating within green economy sectors. After using data allowing a statistical control for omitted variables, the link between environmental and financial performance remains unclear (Telle, 2006).

In our view, the evaluation of waste generation issue combined with the Italian economic structure requires a reverse order of causality: small and medium sized firms – like those largely representing Tuscan economic structure - rarely can benefit from adopting a socially responsible behavior in terms of reputation or product differentiation. On the contrary, Italian firms face generally high cost of waste disposal and this constitutes a significant stimulus to improve their environmental performance (i.e. to reduce waste). However, SMEs are frequently financially constrained and funds for investment are relatively scarce: thus environmental-friendly investments are more likely for profitable (and dynamic) firms, which have internal resources to invest. The link between profitability and environmental performance can thus be ascribed to the fact that profitable firms are frequently innovation-oriented and financially autonomous.

Notwithstanding the fact that the "it pays to be green" dispute is still unsolved, recent empirical literature has stressed that, in order to avoid spurious correlations, the use of micro-data is very important. After a brief overview on waste generation in Tuscany, the following paragraphs present the main features of the micro data set and our empirical estimation analysis.

4.1 Waste generation in Tuscany

Total waste generation in Tuscany is higher than Italian and European average. Behind this value there is a high waste municipal/household production and a relatively low level of waste generated by economic activity, if compared with other European areas.

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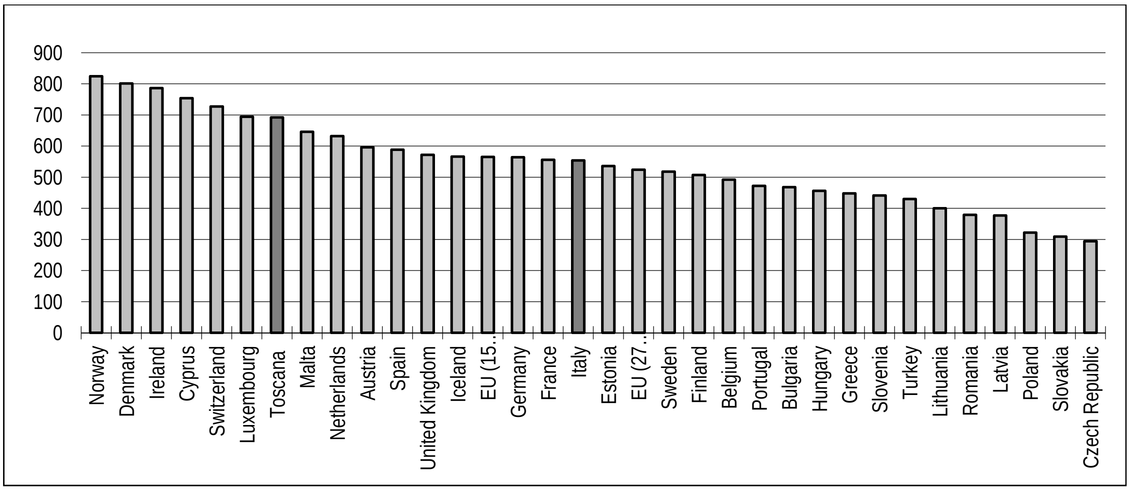
[8] The skeptic view is associated with Palme et al. (1995). The consequences of this debate are very important and manifolds: if it pays to be green, policymakers can disregard short run costs imposed by environmental policy to firms because in the medium run they will innovate more and increase their profits. At the same time, social responsible behavior is remunerative and this can lead to a weaker pressure for environmental regulation as the profit behavior of firms or voluntary agreement can solve many problems.

[9] For a recent analysis of environmental performance (measured by CO_2 emissions) and firm growth in Italy see Mazzanti and Zoboli (2009).

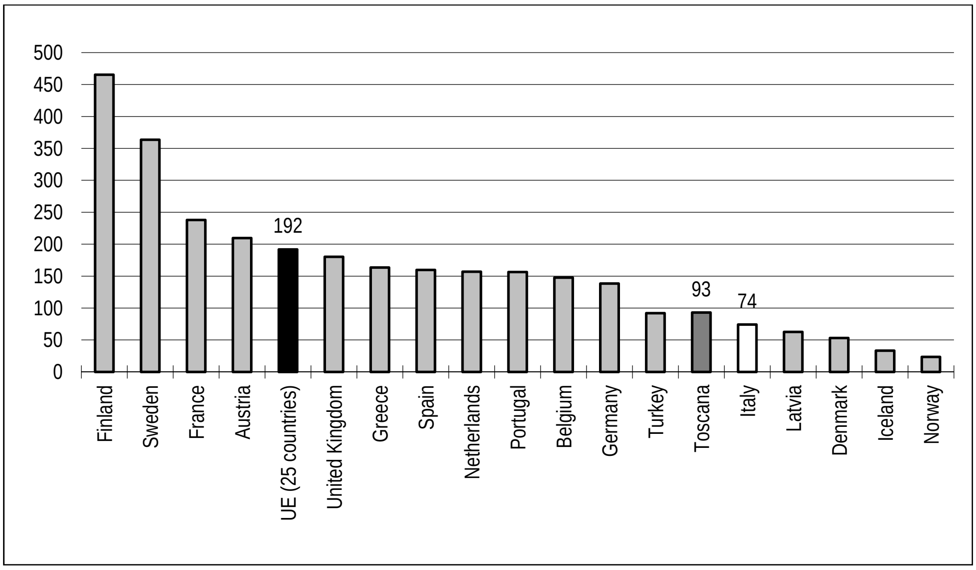
[10] Some analyses have also been based on case studies like the Exxon oil spill or the Bophal accident. For a survey of studies that estimated a positive relation see Murphy (2002).

Graph 3.a
Municipal waste generation in Europe (2004)
(Kilo per capita)



Source: Irpet (2009)

Graph 3.b
Non Municipal non hazardous waste generation in Europe (2004)
(Tonnes per million of GDP)



Source: Irpet (2009)

With regard to the high level of municipal waste, this figure can partly be explained by the high incidence of touristic attractions in the Region; however, the aforementioned regulation about assimilation (waste generated by firms assimilated to household waste) probably plays an important role: a huge amount of waste from small-industries and commercial enterprises can be classified as municipal, thus distorting the classification between municipal/household and special waste.

Table 3 - Waste Generation in Italy and Tuscany (Thousands tonnes)

	2000	2001	2002	2003	2004	2005
Municipal Waste						
Italy						
Total	28.959	29.409	29.864	30.034	31.150	31.664
Per capita	500	516	521	524	533	539
Tuscany	7,7%	7,8%	7,9%	8,0%	8,0%	8,0%
Total	2.232	2.300	2.370	2.389	2.496	2.524
Per capita	629	653	669	680	693	697
Non Municipal Non Hazardous Waste						
Italy						
Total	55.809	59.359	54.364	57.785	62.532	61.553
Per capita	896	965	861	905	977	947
Tuscany	9,8%	9,0%	9,8%	8,7%	8,1%	7,1%
Total	5.455	5.317	5.307	5.003	5.050	4.389
Per capita	1.538	1.504	1.495	1.397	1.401	1.213

Source: ISPRA-ARPAT

More in general, an above-average share of SMEs has been linked by empirical analysis to a higher level of waste generation, also because production processes may involve quite a lot of transactions among firms. Indeed several specialized "industrial districts"[11] are localized in Tuscany and this implies abundant waste generation, but a high grade of homogeneity of materials to be discarded. Table 4 shows how - within an industrial area - non municipal waste is highly concentrated in one waste category.

Table 4 - Non municipal waste generation in some local labour-defined, industrial areas (2004)

Area	Main waste production activity	Kilo per capita	% on total non municipal waste in area
Colline metallifere	Chemical products	10.775	91%
Val di Serchio (Q)	Pulp and Paper	5.082	76%
Valdarno inferiore	Leather and Textile	4.135	47%
Val di Cornia	Metallurgic process	3.579	80%
Massa Carrara	Non metallic mineral products	3.337	87%
Crete senesi	Non metallic mineral products	3.457	53%
Mugello (Q)	Non metallic mineral products	2.980	54%
Versilia	Non metallic mineral products	2.181	61%
Val di cecina costa (Q)	Waste processing and disposal	2.050	77%
Val di cecina interno (Q)	Non metallic mineral products	2.283	64%

Source: Irpet (2009)

[11]An industrial district can be very briefly defined as a socio-territorial entity where several small and medium sized firms gather and specialize to produce in the same sector of activity. However, Italian National Statistical Office produces a different map of more than 600 economic districts, based on employment and commuting data (Local Labour Systems or Sistemi Locali del Lavoro). In most cases it's possible to find a satisfying correspondence for industrial district areas. Table 4 presents data on Local Labour System.

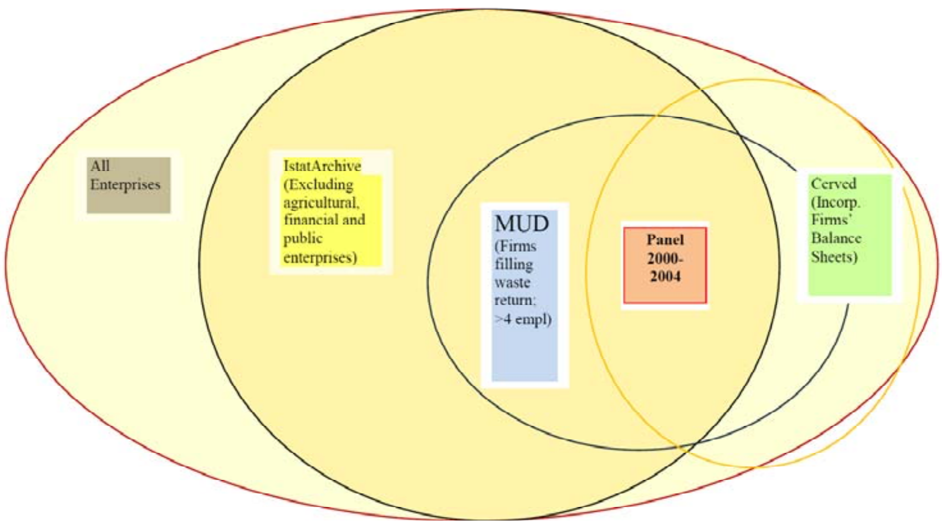
4.2 Non municipal waste generation: a microsimulation analysis

4.2.1 The dataset

In this paper an original dataset of microdata has been built and used. We have used data on special wastes produced by enterprises in Tuscany from 2000 to 2004 which are reported in a form called MUD (Modello Unico di Dichiarazione Ambientale) that firms must fill every year.[12] About 30,000 Tuscan firms are obliged by law to present this waste return, which is around 10 per cent of Tuscan firms reporting to the tax record Office. This information has been merged with demographic and economic data from other statistical sources. In particular, the statistical register of Italian active enterprises (ASIA) has been used as a "spine" for this integration process. First of all data on quantities of waste by EWC codes (European Waste Catalogue codes) have been organized in a dataset by aggregating all different local units of each firm in the region. Then this information has been merged with the ASIA register for Tuscan enterprises[13] and finally with data of CERVED archive[14] to get budget information on corporations included in our data. Therefore we have produced a dataset covering about 7,500 firms with data on waste production by code, on employment and budget items.

Finally, a balanced panel for the period 2000-2004 has been selected (Graph 4). This panel includes 4,338 corporations covering, broadly speaking, mining, manufacturing, and services which produce waste and are active in all five years of the selected period.

Graph 4 - Building the panel



[12] In years 2000-2004 firms obliged to present this waste return were all those producing hazardous waste and those producing non-hazardous waste in industrial processes (excluding small firms with less than 4 employees), in trade and transport services, and in waste removal and disposal activities.

[13] ASIA is produced and maintained by ISTAT (Italian Institute of Statistics). It covers all active enterprises excluding some sectors of economic activities, namely NACE sections A and B (Agriculture and Fishing) , L (Public Sector) , O91, P and Q (other services). Therefore while merging the waste data with the register information, all firms in the sectors specified above are excluded from the new dataset.

[14] CERVED is an archive based on official data filed with Italy's Chambers of Commerce. Information provided includes credit reports, company profiles, summary financial statements (balance sheet, profit & loss accounts and ratios).

The distribution of panel firms by economic activity for the year 2004 is presented in Table 5 : most enterprises belong to manufacturing activities as this is the sector where the largest part of waste is produced (45%), while constructions bear a share of 12 per cent and other services – where the waste disposal services are included – produce 28 per cent of total waste.

Table 5 - Firms distribution by NACE division (2004)

NACE DIVISION	2004	%	Waste (tons)	%	Average waste by firm	Difference from average regional value
PRODUCTS FROM MINING AND QUARRYING	71	1.6	166,700	4.32	2,348	264
MANUFACTURED PRODUCTS	2,934	67.6	1,751,391	45.42	597	67
ELECTRICAL ENERGY, GAS, STEAM AND WATER	13	0.3	158,484	4.11	12,191	1,371
CONSTRUCTION WORK	228	5.3	476,532	12.36	2,090	235
TRADE ; REPAIR OF MOTOR VEHICLES	671	15.5	76,321	1.98	114	13
HOTEL AND RESTAURANT SERVICES	55	1.3	1,692	0.04	31	3
TRANSPORT AND COMMUNICATION SERVICES	105	2.4	93,046	2.41	886	100
REAL ESTATE, RENTING AND BUSINESS SERVICES	85	2.0	42,926	1.11	505	57
EDUCATION SERVICES						
HEALTH AND SOCIAL WORK SERVICES	103	2.4	441	0.01	4	0
OTHER SOCIAL AND PERSONAL SERVICES	56	1.3	1,088,597	28.23	19,439	2,187
SERVICES OF HOUSEHOLDS	17	0.4	74	0.00	4	0
Total	4,338	100%	3,856,207	100%	889	100

As one can see from Table 6, about half of waste generation in Tuscany comes from enterprises with less than 50 workers which in turn represent the 88 per cent of the panel. Average waste generation ranges from 504 tons per worker of SMEs, to more than 16 thousands by large firms.

Table 6 - Total waste and average value by firm dimension (2004)

	Frequency	Total waste (tons)	Average by firm
<50 employees	3,811	1,919,732	504
50-249 employees	469	942,617	2,014
=>250 employees	59	993,858	16,845
Total	4,339	3,856,207	889

While there is an unequivocal direct link between average quantity of waste and firm dimension in terms of employees, there is no clear correlation with firm size when other parameters are taken into account. Medium sized firms (between 50 and 249 employees) exhibit a smaller waste generation, both per unit of value added and per worker, notwithstanding a smaller labour productivity (Table 7).

Table 7 - Waste generation and labour productivity by firm dimension (average 2000-2004)

	Waste per unit of value added	Average per worker	Value added per worker
<50 employees	0.773	32	235
50-249 employees	0.436	20	226
=>250 employees	0.563	40	229
Total	0.734	31	234

Lastly, a distribution of enterprises between Tuscan provinces is presented in Table 8. The largest number of firms is located in the province of Firenze (the richest in term of GDP per capita), where three industrial districts are localized. About 500 firms represent Pisa Arezzo and Prato provinces in the dataset, where 5 districts are localized. The incidence of waste per unit of value added generally reflects the industrial specialization of the area, as in the case of Massa Carrara, where the high incidence is driven by marble industrial residuals.

Table 8 – Firm Distribution by Tuscany provinces (2004)

Provinces	Freq.	Freq (%)	Industrial District (sector specialization and number)	GDP per capita	Waste per Value added (Manufacturing only)
Massa Carrara	218	5,4%	Marble (1)	76,5	1,658
Lucca	435	10,8%	Paper (1)	93,3	0,49
Pistoia	324	8,0%	Leather and footwear (1)	90,2	0,139
Firenze	984	24,4%	Leather and footwear, Textile, clothing (3)	111,3	0,113
Livorno	180	4,5%		94,2	0,134
Pisa	550	13,6%	Leather and footwear (1)	97,4	0,387
Arezzo	474	11,7%	Goldsmith, Leather and footwear, Textile and clothing (3)	92,4	0,061
Siena	314	7,8%	Wood and forniture (2)	98,1	0,205
Grosseto	106	2,6%		85,7	0,231
Prato	454	11,2%	Textile and clothing (1)	99,1	0,078

4.2.2 The model and estimated results

As previously discussed, waste generation and disposal is a topic which can hardly fit into the "it pays to be green" debate. In this paper we assume that the more profitable and dynamic firms are, the more they are likely to invest with the aim of reducing waste disposal costs as a way to further increase profits. Although Tuscan landfill tax doesn't represent a very high disincentive (it ranges between 4 and 25 € per ton), the total waste disposal cost for firms is much higher, depending on waste disposal fees set by private firms operating in this field (see Cewep (2010) for this evaluation). These high disposal costs may signal either inefficiency or market power but, nonetheless, they ultimately can help waste prevention and recycling behavior of firms.

As empirical evidence on this issue is very scant and analyses based upon highly disaggregated panel data on waste is even scarcer, we have decided to apply a fixed effect model to our data in order to identify if certain firm-specific characteristics including profitability, age , economic activity sector, and dimension, may influence firm behavior in producing a certain amount of waste per unit of value added. The fixed effect model has been chosen in order to overcome some shortcomings of the methods which are usually applied in these studies. Omitted variables bias tends to be relevant when exploring issues where there is large heterogeneity of firms: the fixed effects model can capture the unobserved variables at the firm level – such as the adoption of energy-saving technology, the management attention to waste produced during the production process – that influence the behavior of the firm. In this case we take into account the panel structure of the data and, supposing the relevance of company specific fixed effects, we allow the intercepts to be different for each firm to control for firm heterogeneity. The general model we propose to estimate is the following:

$$waste\_VA_{it} = \alpha_i + \beta_1 ROS_{it} + \beta_2 Inv\_sales_{it} + \beta_3 age_{it} + \beta_4\ province_{it} + u_i + \varepsilon_{it} \qquad (1)$$

The total quantity of waste per unit of value added is a function of two variables measuring economic performance, of the age of the firm and of the province where the firm is located. As measure of profitability we use the firm return on sales (*ROS*) which is calculated for firm i in the year t as sales minus production costs divided by sales. As suggested by Telle (2006), this is an adequate measure of economic performance when a dataset covers a relatively short period because financial costs of investments are not included in this variable thus high investments (also environmentally related) which may hamper profitability in the short term will not interphere with the effect of this variable over the waste generation of the firm. The share of tangible assets on sales (*Inv_sales*) is used to measure if firm size in terms of fixed capital affects the quantity of waste per unit of value added. The demographic characteristics of age and geographical location of the firm are useful to verify if young/old firms behave differently and if the costs of waste disposal which are specific by province may influence the quantity of waste produced: this information may be very useful for implementing effective environmental policies. Finally, the latent heterogeneity of the panel is captured by the unobserved variables at the firm level u_i.

This model has been estimated over the panel considering all economic activities but excluding the sectors of mining and of constructions which have peculiar characteristics in terms of waste weight and disposal regulation. Table 9 presents summary statistics for the main variables used in the econometric analysis.

Table 9 - Descriptive analysis of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
waste_VA	19732	0.26	0.95	-0.46	12.19
ros	19712	0.29	0.17	-0.18	0.78
inv_sales	19692	0.21	0.28	0.00	2.74
age	20200	18.50	12.25	0	102

Estimation results of model (1) are presented in Table 10. The measure of firm profitability (ROS) has a negative effect on waste per unit of value added, and this sign is stable also in other estimates shown in the following. This result can be interpreted in the sense that more profitable and dynamic firms indeed generate less waste as well as the smaller is the firm in terms of capital assets. The age of firms is not statistically significant, while there are some different effects due to the location of the firm. With respect to the reference omitted province (Firenze), enterprises operating in Arezzo (mainly in furniture production and other manufacturing) produce less waste per unit of value added.

Table 10 – Fixed effect model – All economic activities (excluding mining and costructions)

Fixed-effects (within) regression

R-sq: within = 0.0168			Number of obs		18977	
between = 0.0000			Number of groups		4010	
overall = 0.0000						

waste_VA	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
inv_sales	0.1166602	0.0535471	2.18	0.029	0.0116782	0.2216422
ros	-0.8251412	0.1087953	-7.58	0	-1.03844	-0.611842
age	0.0038951	0.0024734	1.57	0.115	-0.0009541	0.0087443
Massa Carrara	(dropped)					
Lucca	0.9065993	0.752062	1.21	0.228	-0.5678604	2.381059
Pistoia	0.9118533	0.752498	1.21	0.226	-0.563461	2.387168
Livorno	-0.2257967	0.3142857	-0.72	0.473	-0.8419714	0.390378
Pisa	-0.6055173	0.5229785	-1.16	0.247	-1.630846	0.4198113
Arezzo	-0.0064094	0.0023587	-2.72	0.007	-0.0110337	-0.001785
Siena	0.043003	0.0271059	1.59	0.113	-0.0101396	0.0961455
Grosseto	(dropped)					
Prato	-0.0400499	0.0462598	-0.87	0.387	-0.1307447	0.050645
_cons	0.3233827	0.1774886	1.82	0.069	-0.0245936	0.6713589
sigma_u	1.1811292					
sigma_e	0.3807354					
rho	0.90587206	(fraction of variance due to u_i)				

We believe that firms in manufacturing have specific characteristics with respect to waste production, therefore we have decided to further explore this subset of firms and to verify if a variance exists even within this group by adding to model (1) sectoral dummies for NACE economic activities ranging between division 15 (food products and beverages) and 36 (furniture and other manufactured goods). The model for manufacturing firms takes the following form:

$$\begin{aligned} waste\_VA_{it} = \alpha_i + \beta_1 ROS_{it} + \beta_2 Inv\_sales_{it} + \beta_3 age_{it} + \beta_4\ province_{it} + \\ + \beta_5 (dum\_subsector)_t + u_i + \varepsilon_{it} \end{aligned} \qquad (2)$$

Furthermore, we have decided to run this model for two different groups of companies to verify how firm size (in terms of number of workers) affects the link between waste generation, profitability and investment. Model (2) has thus been estimated on manufacturing enterprises below and over 50 employees.

Results for smaller firms (which are the largest group in our panel) are presented in Table 11 while estimated effects for larger firms are in Table 12. The signs of the profitability and investment variables are confirmed, although the magnitude of estimated parameters between the two groups differs: for larger firms the effect of return on sales is more than 30 per cent higher than for smaller firms while the share of tangible assets becomes statistically not significant for the first group. The geographic location is relevant for the presence in some specific areas of very large establishments which may distort our estimates especially in the case of larger firms where the number of observations in our estimated model is much reduced (1723 observations compared with 12,429 for smaller manufacturing firms). On the other hand, for firms of smaller size located in all provinces but Siena, the geographical location reduces the effect on waste compared with Firenze, probably due to different municipal regulations and, in some cases, to the assimilation criteria of industrial waste to municipal waste. As for the effect of the sectoral dummies (the reference omitted sector being 'leather and leather products') we may notice that, for firms of larger size, the prevalent economic activity has a very significant differential effect over the quantity of waste per unit of value added.

Table 11 – Estimated results: manufacturing firms with less than 50 workers

Fixed-effects (within) regression

R-sq: within = 0.0228 Number of obs 12429

between = 0.0003

overall = 0.0000

waste_VA	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
inv_sales	0.145977	0.0496189	2.94	0.003	0.0486824	0.243272
ros	-0.79363	0.1157004	-6.86	0	-1.020505	-0.56676
age	0.000211	0.0025724	0.08	0.935	-0.0048332	0.005255
Massa_Carrara	(dropped)					
Lucca	-0.01626	0.0601056	-0.27	0.787	-0.1341185	0.101597
Pistoia	-0.0507	0.0573347	-0.88	0.377	-0.1631275	0.061721
Livorno	-0.99968	0.0692137	-14.44	0	-1.135394	-0.86396
Pisa	-0.74397	0.6433505	-1.16	0.248	-2.005483	0.517537
Arezzo	-0.01671	0.0078173	-2.14	0.033	-0.0320351	-0.00138
Siena	0.060483	0.0077552	7.8	0	0.0452759	0.07569
Grosseto	(dropped)					
Prato	-0.03469	0.0107424	-3.23	0.001	-0.0557552	-0.01363
food and beverages	-0.18205	0.1404762	-1.3	0.195	-0.4575053	0.093398
textiles	-0.27518	0.1923927	-1.43	0.153	-0.6524305	0.102074
wearing apparel	-0.34822	0.2210448	-1.58	0.115	-0.781657	0.085212
wood	-0.56872	0.3190874	-1.78	0.075	-1.194403	0.056958
paper products	-0.18802	0.1612833	-1.17	0.244	-0.5042676	0.128235
printed matter and rec.	-0.16479	0.1565161	-1.05	0.292	-0.4716962	0.142111
coke and petrol. products	-0.04229	0.2087057	-0.2	0.839	-0.4515267	0.366952
chemicals	-0.14713	0.140625	-1.05	0.296	-0.4228785	0.128609
rubber and plastic	-0.10654	0.1445983	-0.74	0.461	-0.3900736	0.176996
non metallic products	-0.21282	0.1508451	-1.41	0.158	-0.5086012	0.082966
basic metals	-0.34258	0.1793605	-1.91	0.056	-0.6942752	0.009121
fabricated metal products	-0.19151	0.153549	-1.25	0.212	-0.4925979	0.109574
machinery and equipm.	-0.21751	0.1518515	-1.43	0.152	-0.5152625	0.080252
office machinery	-0.25794	0.1533721	-1.68	0.093	-0.5586786	0.042799
eletrical machinery	-0.22298	0.1524674	-1.46	0.144	-0.5219426	0.075987
radio and television	-0.28901	0.1552828	-1.86	0.063	-0.5934909	0.01548
medical and optic.instr.	-0.1913	0.1492298	-1.28	0.2	-0.483921	0.101312
motor vehicles	-0.14076	0.1615831	-0.87	0.384	-0.4576	0.176078
transport equipment	-0.25548	0.168397	-1.52	0.129	-0.5856804	0.07472
furniture and other man.	-0.28538	0.1641846	-1.74	0.082	-0.6073226	0.036558
_cons	0.817276	0.1594935	5.12	0	0.5045339	1.130018
sigma_u	1.168967					
sigma_e	0.346241					
rho	0.919345	(fraction	of variance due	to	u_i)	

Table 12 – Estimated results: manufacturing firms with more than 50 workers

Fixed-effects (within) regression						
R-sq: within = 0.1325		Number of obs	1723			
between = 0.0040						
overall = 0.0025						
waste_VA	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
inv_sales	0.0946091	0.0708789	1.33	0.183	-0.0447012	0.2339195
ros	-1.21488	0.4270402	-2.84	0.005	-2.054215	-0.3755446
age	0.0004141	0.0055754	0.07	0.941	-0.0105441	0.0113723
Massa_Carrara	(dropped)					
Lucca	(dropped)					
Pistoia	3.854874	0.0405469	95.07	0	3.77518	3.934568
Livorno	(dropped)					
Pisa	-0.0293629	0.0170983	-1.72	0.087	-0.0629692	0.0042433
Arezzo	(dropped)					
Siena	(dropped)					
Grosseto	(dropped)					
Prato	0.0003786	0.0366694	0.01	0.992	-0.0716941	0.0724513
food and beverages	(dropped)					
textiles	-0.0394122	0.0302663	-1.3	0.194	-0.0988999	0.0200754
wearing apparel	0.0268745	0.0274608	0.98	0.328	-0.0270989	0.0808479
wood	(dropped)					
paper products	0.0029107	0.0133159	0.22	0.827	-0.0232613	0.0290827
printed matter and rec.	(dropped)					
coke and petrol. products	(dropped)					
chemicals	1.053589	0.0687081	15.33	0	0.9185453	1.188633
rubber and plastic	1.014899	0.0810316	12.52	0	0.855634	1.174164
non metallic products	1.049094	0.0819368	12.8	0	0.8880496	1.210138
basic metals	0.96247	0.1098698	8.76	0	0.7465243	1.178416
fabricated metal products	1.021487	0.0934409	10.93	0	0.8378313	1.205142
machinery and equipm.	1.049604	0.0770214	13.63	0	0.8982202	1.200987
office machinery	(dropped)					
eletrical machinery	1.135285	0.0717042	15.83	0	0.9943527	1.276218
radio and television	(dropped)					
medical and optic.instr.	-0.0620795	0.0425771	-1.46	0.146	-0.1457636	0.0216046
motor vehicles	0.9900791	0.0805518	12.29	0	0.8317569	1.148401
transport equipment	1.089573	0.0838667	12.99	0	0.9247351	1.25441
furniture and other man.	1.037335	0.0872962	11.88	0	0.8657573	1.208914
_cons	-0.3353302	0.1958896	-1.71	0.088	-0.7203454	0.0496849
sigma_u	1.2805522					
sigma_e	0.24834934					
rho	0.96375098	(fraction	of variance due	to	u_i)	

5. Concluding Remarks

Waste minimization and efficient management are policy makers' priority around the world, and in some cases they represent an emergency, as in the case of the South of Italy. There has been considerable literature analyzing household waste generation and municipal waste management in the last decades, but only little research is concerned with waste generated by firms, notwithstanding this category accounts for over the eighty per cent of total waste.

Understanding firm's behavior concerning waste generation appears a key objective in order to set appropriate policy instruments. Can waste minimization be linked to social responsibility- related choices that allow firms to earn more profits in the medium run or must it be linked mainly to market-based incentives? In this paper we briefly recall the social responsibility and financial profitability literature, also known as the "it pays to be green" debate, but it is evident that empirical analyses have not reached a definitive conclusion on this issue. On the contrary, in the case of waste generation, we believe that it does not pay to be green for Italian SMEs and an improvement of environmental performance needs regulation and market-based incentives. Italian firms face up high costs of waste disposal, which derive more from inefficiency in waste collection than from policy signals. These high costs constitute an incentive to waste minimization, an activity that usually needs important investments in new technologies. However, SME are frequently financially constrained and funds for investment are relatively scarce: thus environmental-friendly investments are more likely for profitable (and dynamic) firms, which have internal resources to invest.

In order to test this hypothesis we employed a new panel dataset with detailed information on waste generation, sector of activity, localization, employment and financial performance of more than 4000 Tuscan corporations. We run fixed effect regressions and found a statistically significant link between waste generation, profitability and investments for Tuscan firms, controlling for sector and localization within the region. Moreover we found evidence of differentiated behavior between small (less than 50 workers) and medium-large firms.

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